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THE INTRODUCTION AND COLONIZATION IN PUERTO RICO OF BENEFICIAL INSECTS

BY

KENNETH A. BARTLETT, ASSISTANT ENTOMOLOGIST,
DIVISION OF FOREIGN PARASITE INTRODUCTION,
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
UNITED STATES DEPARTMENT OF AGRICULTURE /A

BENEFICIAL INSECTS ARE INTRODUCED INTO PUERTO RICO TO CONTROL CROP PESTS.

THE INTRODUCTION OF BENEFICIAL INSECTS TO PUERTO RICO WAS A PROJECT UNDERTAKEN BY THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE TO AID PUERTO RICAN AGRICULTURE IN THE CONTROL OF INSECT PESTS. THE INVESTIGATIONS WERE ORIGINALLY FINANCED UNDER THE PUERTO RICO (SUGAR PROCESSING) TAX FUND, ORDER NUMBER 2, AND LATER WITH FUNDS PROVIDED BY A CONGRESSIONAL APPROPRIATION. THESE INVESTIGATIONS STARTED IN JULY 1935 AND SINCE SEPTEMBER 30, 1936, HAVE BEEN CONTINUED AS A PROJECT OF THE PUERTO RICO AGRICULTURAL EXPERIMENT STATION. THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE IS COOPERATING IN THE CONTINUANCE OF THIS PROJECT AND THE TECHNICAL DIRECTION OF THE WORK REMAINS IN THE DIVISION OF FOREIGN PARASITE INTRODUCTION OF THAT BUREAU. THE AUTHOR WISHES TO

/A. NOW ASSOCIATE ENTOMOLOGIST, PUERTO RICO EXPERIMENT STATION, UNITED STATES DEPARTMENT OF AGRICULTURE.

TAKE THIS OPPORTUNITY TO EXPRESS HIS APPRECIATION OF THE FACILITIES PROVIDED BY THE EXPERIMENT STATION AND TO THANK THE DIRECTOR, AND HIS ASSOCIATES, FOR THEIR COOPERATION AND HELPFUL ADVICE ON MANY OF THE PROBLEMS ENCOUNTERED.

BENEFICIAL INSECTS ARE DIVIDED INTO TWO MAIN TYPES, PARASITES AND PREDATORS.

IN A DISCUSSION OF BENEFICIAL INSECTS THE WORDS PARASITE AND PREDATOR ARE COMMONLY USED. A DEFINITION OF THESE TWO TERMS MAY CLARIFY ANY CONFUSION THAT MAY RESULT FROM THEIR USE. FROM THE ENTOMOLOGICAL VIEWPOINT AN INSECT PARASITE IS AN INSECT THAT EITHER ATTACHES ITSELF TO ITS HOST, A TERM APPLIED TO THE INSECT ATTACKED, AND THUS FEEDS FROM THE OUTSIDE THROUGHOUT ITS DEVELOPMENT, OR THE PARASITE ENTERS THE BODY OF ITS HOST AND FEEDS WITHIN. IN THE FORMER CASE THE PARASITE IS CALLED AN EXTERNAL PARASITE AND IN THE LATTER AN INTERNAL PARASITE. AN INSECT PREDATOR IS ONE THAT IS FREE MOVING THROUGHOUT ITS LIFE AND FEEDS EXTERNALLY ON ITS HOST. SINCE A PARASITE LIVES EITHER ATTACHED TO OR INSIDE ITS HOST, ONE INDIVIDUAL PARASITE THUS CAN KILL ONLY ONE HOST INSECT, WHILE A PREDATOR, BEING FREE TO MOVE ABOUT FROM ONE HOST TO ANOTHER, USUALLY KILLS NUMEROUS HOST INSECTS DURING ITS LIFE HISTORY. THE CONTROL OF INJURIOUS AND HARMFUL INSECTS BY MEANS OF OTHER ORGANISMS, BOTH ANIMAL AND PLANT, HAS BEEN CALLED NATURAL OR BIOLOGICAL CONTROL.

PARASITES AND PREDATORS OTHER THAN INSECTS ALSO CONTROL CROP PESTS.

THIS PROJECT IS PRIMARILY CONCERNED WITH THE INTRODUCTION OF INSECT PARASITES AND PREDATORS OF INJURIOUS INSECTS AFFECTING AGRICULTURAL CROPS IN PUERTO RICO. THERE ARE OTHER LIVING ORGANISMS, HOWEVER, WHICH MAY PLAY AN IMPORTANT PART IN BIOLOGICAL CONTROL AND THEREFORE SHOULD RECEIVE MENTION. SOME OF THESE MORE IMPORTANT PARASITES AND PREDATORS ARE FUNGI, BACTERIA, NEMATODES, BIRDS, AND OTHER INSECTIVOROUS ANIMALS. WHILE FUNGI AND BACTERIA ARE OF IMPORTANCE AND HAVE PROVED OF VALUE IN REDUCING INSECT PESTS, EVIDENCE TO DATE INDICATES THAT THEIR VALUE IS LIMITED BY FACTORS OF SMALL HOST

POPULATION AND ENVIRONMENTAL CONDITIONS UNFAVORABLE FOR THEIR DEVELOPMENT. THE INTRODUCTION OF ENTOMOGENOUS FUNGI TO NEW LOCALITIES HAS NOT PROVED OF GREAT VALUE IN EXPERIMENTS TO DATE, BUT MORE WORK ALONG THIS LINE SEEMS JUSTIFIED.

THE INTRODUCTION AND VALUE OF NEMATODES FOR BIOLOGICAL CONTROL STILL REMAINS IN THE EXPERIMENTAL STAGE. ONE SUCH INTRODUCTION HAS BEEN MADE INTO PUERTO RICO DURING THE COURSE OF THIS PROJECT. IT SHOULD BE BORNE IN MIND, HOWEVER, THAT PRESENT KNOWLEDGE INDICATES THAT WITH FEW EXCEPTIONS NEMATODES HAVE SEEMED TO PLAY A SMALL PART IN BIOLOGICAL CONTROL IN THEIR NATIVE HABITATS. ONE OF THE WELL KNOWN NEMATODES IS HEXAMERIS MERIDIONALIS, A PARASITE OF LOCUSTS, GRASSHOPPERS, AND OTHER PESTS. THIS NEMATODE HAS A WIDE DISTRIBUTION AND PLAYS A PART IN THE BIOLOGICAL CONTROL OF THESE PESTS.

THE INTRODUCTION OF BIRDS OR OTHER ANIMALS AS A MEANS OF BIOLOGICAL CONTROL IS A PRACTICE WHICH MANY TIMES IN THE PAST HAS PRODUCED A RESULT THE VALUE OF WHICH IS OPEN TO QUESTION. THERE ARE ALSO CASES, SUCH AS THAT OF THE GIANT TOAD, BUFO MARINUS, WHICH HAVE PROVED TO BE OF GREAT VALUE. THE DISAPPEARANCE OF WHITE GRUBS, PHYLLOPHAGA SPP., IN THE LOWLANDS OF PUERTO RICO CAN PROBABLY BE ATTRIBUTED TO THIS TOAD, INTRODUCED FOR INSECT CONTROL FROM BARBADOS IN 1920 AND FROM JAMAICA IN 1923-24. THE FOOD HABITS OF SUCH LARGER ANIMALS, HOWEVER, ARE SO MUCH MORE DIVERSIFIED THAN IN THE CASE OF MOST OF THE INSECT PARASITES AND PREDATORS THAT SUCH INTRODUCTIONS NEED CAREFUL INVESTIGATION OF ALL POSSIBLE RESULTS IN EACH INDIVIDUAL CASE. THE FAILURES, RESULTANT LOSSES, AND THE PUBLIC CONDEMNATION OF SOME SUCH INTRODUCTIONS HAVE TENDED TO CREATE A SLIGHT FEELING OF DISTRUST IN REGARD TO BIOLOGICAL CONTROL AMONG SOME OF THE AGRICULTURAL POPULATION OF THE COUNTRIES WHERE IT HAS BEEN TRIED.

BENEFICIAL INSECTS ARE CARNIVOROUS FEEDERS AND CAN NEVER INJURE AGRICULTURAL CROPS.

THE QUESTION IS OFTEN RAISED AS TO THE POSSIBILITY OF AN INTRODUCED BENEFICIAL INSECT BECOMING A PEST OF SOME AGRICULTURAL CROP IN ITS NEW HOME. IN THIS CONNECTION

IT CAN BE STATED WITH ABSOLUTE ASSURANCE THAT A TRUE INSECT PARASITE OR PREDATOR CAN NEVER BECOME A PEST OF AN AGRICULTURAL CROP. INSECT PARASITES AND PREDATORS ARE LIMITED BY THEIR METHODS OF REPRODUCTION AND BY THEIR FEEDING HABITS TO ATTACKS ON OTHER INSECTS, AND THE POSSIBILITY OF THEIR BECOMING PLANT FEEDERS DOES NOT EXIST. THESE FACTS, HOWEVER, EMPHASIZE THE POINT THAT IT IS NECESSARY, IN ORDER TO INTRODUCE ONLY SUCH INSECTS AS ARE BENEFICIAL, THAT ALL SUCH INTRODUCTIONS BE HANDLED BY TRAINED ENTOMOLOGISTS WHO KNOW THE HABITS OF THE INSECTS WITH WHICH THEY ARE WORKING.

IN THE INTRODUCTION OF BENEFICIAL INSECTS IT IS ALSO NECESSARY THAT EXTREME CARE BE TAKEN TO PREVENT THE INTRODUCTION OF ANY OF THE INSECT PARASITES WHICH LIVE UPON THESE BENEFICIAL INSECTS AND WHICH ARE KNOWN AS SECONDARY PARASITES OR HYPER-PARASITES. THESE SECONDARY PARASITES, BY FEEDING ON AND KILLING THE BENEFICIAL SPECIES, WOULD MINIMIZE THE VALUE OF THE BENEFICIAL INSECT, OR PRIMARY PARASITE, IN CONTROLLING ITS HOST. TO ELIMINATE THE POSSIBILITY OF INTRODUCING HYPERPARASITES, BY FAR THE GREATEST NUMBER OF INTRODUCTIONS INTO PUERTO RICO WERE MADE IN THE ADULT STAGE.

DURING THE COURSE OF THE PROJECT A PARASITE INSECTARY WAS BUILT ON THE EXPERIMENT STATION GROUNDS. THIS BUILDING IS SO CONSTRUCTED AS TO PREVENT THE ESCAPE OF VERY MINUTE INSECTS THROUGH THE SCREENED WALLS. IN ADDITION, THE INSECTS THAT ARE BEING HANDLED ARE HELD IN INSECT-PROOF CAGES WITHIN THIS BUILDING. IF THE MATERIAL IS SHIPPED TO PUERTO RICO AS PARASITIZED HOST INSECTS, AND HYPERPARASITES ARE LIKELY TO BE PRESENT, FURTHER PRECAUTIONS ARE TAKEN BY PLACING A CAGE WITHIN A CAGE TO PREVENT ANY POSSIBLE ESCAPE OF THE UNDESIRABLE SPECIES.

THE DEVELOPMENT OF CIVILIZATION HAS UPSET THE BALANCE OF NATURE.

THE IMPORTANCE OF INSECTS AND THE PART THEY PLAY IN OUR ECONOMIC LIFE HAS BEEN MORE GENERALLY APPRECIATED IN LATE YEARS. IT HAS BEEN SAID THAT IF MAN IS TO BE WIPED FROM THE FACE OF THE EARTH, INSECTS WILL BE HIS CONQUEROR. THE CONDITION UNDER WHICH INSECTS CAUSE SERIOUS CROP DAMAGE HAS BEEN THE RESULT OF AN UPSET OF THE BALANCE

OF NATURE BY MAN. AGRICULTURAL CROPS HAVE BEEN EXCHANGED THE WORLD OVER AND A CROP ONCE FOUND ONLY IN A CERTAIN ENVIRONMENT IS NOW FOUND IN ALL ENVIRONMENTS IN WHICH IT CAN BE ESTABLISHED. IN ADDITION, THE REQUIREMENTS OF THE HUMAN RACE HAVE NECESSITATED GROUP PLANTINGS OF THE SAME PLANT SPECIES OVER WIDE AREAS IN CONTRAST TO CONDITIONS WHICH OCCUR IN NATURE.

BENEFICIAL INSECTS AID IN THE ECONOMICAL CONTROL OF INSECTS THAT DAMAGE CROPS.

FOR MANY YEARS ENTOMOLOGISTS AND OTHERS HAVE OBSERVED THAT MOST INSECTS ARE ATTACKED BY OTHER INSECTS THAT FEED UPON THEM AS EITHER PREDATORS OR PARASITES. IN THIS WAY A CHECK IS PROVIDED IN NATURE TO LIMIT THE RAVAGES OF ANY INSECT OR GROUP OF INSECTS.

UNFORTUNATELY THE MOVEMENT OF PLANTS FROM ONE COUNTRY OR EVEN CONTINENT TO ANOTHER HAS OFTEN BEEN ACCOMPANIED BY A MOVEMENT OF THEIR INSECT PESTS. THESE INSECT PESTS IN A NEW ENVIRONMENT, FAVORED BY MASS PLANTINGS OF THEIR HOST FOOD CROP AND ALSO OFTEN FAVORED BY THE LACK OF ENEMIES, I. E., BIOLOGICAL CONTROL, HAVE INCREASED RAPIDLY AND BECOME A SERIOUS PROBLEM TO THE WELFARE OF MAN.

THE UNDERLYING SEQUENCE OF EVENTS CAUSING AN INSECT SCOURGE OF A CROP PLANT IS USUALLY SOMETHING AS FOLLOWS: A CROP PLANT IS FOUND GROWING IN ITS COUNTRY OF ORIGIN AND, BEING OF VALUE, IS TRANSPORTED TO A NEW COUNTRY. THE CROP PLANT MAY BRING WITH IT ONE OR SEVERAL OF ITS INSECT PESTS. THESE INSECT PESTS IN THEIR COUNTRY OF ORIGIN MAY HAVE ONE OR SEVERAL NATURAL ENEMIES, AND THE LATTER IN TRANSPORTATION MAY BE LEFT BEHIND. THE CROP INSECTS THEN FIND THEMSELVES IN A NEW COUNTRY FREE OF ALL OR MOST OF THEIR BIOLOGICAL ENEMIES, AND CONSEQUENTLY MULTIPLY WITHOUT NATURAL CHECKS; AS A RESULT, THE CROP INSECTS BECOME A MUCH MORE DAMAGING FACTOR IN THE NEW COUNTRY THAN IN THE COUNTRY OF ORIGIN.

IT IS UNDER SUCH CONDITIONS THAT PROJECTS FOR THE BIOLOGICAL CONTROL OF AN INSECT PEST OF CROPS HAVE THE BEST CHANCE OF SUCCESS.

THEORY WOULD INDICATE THAT A STUDY OF THE INSECT PEST IN THE COUNTRY OF ITS ORIGIN AND IN THE COUNTRY OF ORIGIN OF ITS HOST PLANT MIGHT REVEAL ONE OR SEVERAL NATURAL ENEMIES OF THE CROP PEST NOT PRESENT IN THE NEW COUNTRY. THE APPLICATION OF SUCH THEORY HAS OFTEN RESULTED IN FINE SUCCESS, AND THESE NATURAL ENEMIES WHEN TRANSPORTED FROM THE COUNTRY OF ORIGIN AND COLONIZED IN THE NEW COUNTRY HAVE BROUGHT ABOUT THE ECONOMIC CONTROL OF INSECT DEPREDATIONS OR AT LEAST REDUCED THE DAMAGE BEING CAUSED BY INSECT PESTS.

BIOLOGICAL CONTROL IS ECONOMICAL AND SELF-SUSTAINING.

THE ADVANTAGES OF SUCH BIOLOGICAL CONTROL OF INSECT PESTS ARE THAT THESE BENEFICIAL INSECTS WHEN INTRODUCED AND ESTABLISHED CONTINUE TO WORK NIGHT AND DAY, WEEK DAYS AND HOLIDAYS, WITHOUT FURTHER COST TO THE GROWER. THE USE OF POISONOUS SPRAYS, WHILE OFTEN VERY EFFECTIVE IN INSECT CONTROL, MEANS A REPEATED FINANCIAL OUTLAY YEAR AFTER YEAR. THE CONTROL OF INSECT PESTS BY BIOLOGICAL MEANS IS, THEREFORE, BEING MORE APPRECIATED IN RECENT YEARS THAN FORMERLY AND CERTAIN CASES OF LARGE FINANCIAL RETURNS ACCRUING FROM THE INTRODUCTION OF BENEFICIAL INSECT SPECIES ARE WELL KNOWN.

THE UNITED STATES DEPARTMENT OF AGRICULTURE HAS A BROAD BACKGROUND FOR CONTROL OF PESTS BY BENEFICIAL INSECTS.

THE FIRST EXPLORATORY WORK BY THE UNITED STATES DEPARTMENT OF AGRICULTURE TO SECURE INSECT PARASITES WAS IN THE YEAR 1888, WHEN A SEARCH WAS MADE FOR NATURAL ENEMIES OF THE COTTONY CUSHION SCALE, AT THAT TIME A SERIOUS PEST OF CITRUS IN CALIFORNIA. ONE OF THESE FIRST INTRODUCTIONS WAS THAT OF THE LADYBIRD BEETLE, RODOLIA (NOVIUS) CARDINALIS MULS. PREVIOUS TO ITS INTRODUCTION THE CITRUS FRUIT INDUSTRY WAS THREATENED WITH DESTRUCTION BY THE COTTONY CUSHION SCALE, WHICH HAD BEEN INTRODUCED ACCIDENTALLY FROM AUSTRALIA. INVESTIGATIONS SHOWED THAT IN AUSTRALIA THIS PEST HAD SEVERAL NATURAL ENEMIES. ONE OF THESE BENEFICIAL INSECTS, THE VEDALIA BEETLE, AS THE LADYBIRD BEETLE JUST REFERRED TO WAS THEN CALLED, WAS BROUGHT TO CALIFORNIA AND COLONIZED THERE IN THE

ORANGE GROVES IN 1888-89. THE BEETLE ATTACKED THE SCALE SO EFFECTIVELY THAT IN THE COURSE OF A FEW YEARS THE PEST WAS UNDER COMPLETE CONTROL, AND NOW ONLY AN OCCASIONAL LOCAL AND TEMPORARY OUTBREAK OCCURS.

SINCE THAT TIME EXPLORATIONS HAVE BEEN MADE IN REPRESENTATIVE AREAS COVERING THE ENTIRE WORLD. THE MOST EXTENSIVE INVESTIGATIONS HAVE BEEN UPON THE NATURAL ENEMIES OF THE GYPSY AND BROWN-TAIL MOTHS, THE EUROPEAN CORN BORER, THE JAPANESE BEETLE, AND THE CITRUS BLACK FLY. AT THE PRESENT TIME THE UNITED STATES DEPARTMENT OF AGRICULTURE MAINTAINS TWO FOREIGN LABORATORIES, ONE IN EUROPE AND THE OTHER IN THE ORIENT, DEVOTED PRINCIPALLY TO THE SEARCH FOR BENEFICIAL INSECTS THROUGHOUT THESE AREAS.

FURTHER EXPLORATIONS FOR BENEFICIAL INSECTS WERE UNDERTAKEN DURING 1935 AND 1936.

AS A PART OF THE PROGRAM TO INTRODUCE BENEFICIAL INSECTS TO PUERTO RICO, EXPLORATORY INVESTIGATIONS WERE CONDUCTED IN TRINIDAD, BRITISH GUIANA, AND PERU. AN ENTOMOLOGIST, S. M. DOHANIAN, ASSIGNED TO THE PROJECT OF THE INTRODUCTION OF NATURAL ENEMIES TO PUERTO RICO, CONDUCTED THESE INVESTIGATIONS AND SHIPPED A LARGE NUMBER OF INSECT PARASITES AND PREDATORS TO PUERTO RICO DURING 1935 AND 1936.

PUERTO RICO ALSO RECEIVED PARASITES AS A RESULT OF EXPLORATORY WORK CONDUCTED IN BRAZIL AND EAST AFRICA UNDER PROCESSING TAX FUNDS ALLOTTED TO HAWAII. IN RETURN SEVERAL SHIPMENTS OF NATIVE INSECT PARASITES WERE MADE FROM PUERTO RICO TO HAWAII.

BENEFICIAL INSECTS WERE ALSO RECEIVED FROM THE CONTINENTAL UNITED STATES, HAWAII, MEXICO, AND FIJI.

A LARGE NUMBER OF BENEFICIAL INSECTS WERE RECEIVED FROM ESTABLISHED LABORATORIES OF THE BUREAU OF ENTOMOLOGY IN THE UNITED STATES. IN ADDITION THE LABORATORY OF THE DIVISION OF FRUITFLY INVESTIGATIONS SHIPPED PARASITES OF FRUITFLIES FROM THEIR LABORATORIES IN MEXICO, PANAMA, AND HAWAII. A SHIPMENT OF PREDATORY BEETLES WHICH ATTACK THE BANANA ROOT WEEVIL WAS RECEIVED FROM FIJI THROUGH THE COOPERATION OF THE BRITISH AUTHORITIES.

AIRPLANE TRANSPORTATION IS UTILIZED TO ADVANTAGE IN THE INTRODUCTION OF BENEFICIAL INSECTS.

WITH VERY FEW EXCEPTIONS ALL OF THE PARASITE SHIPMENTS MADE DURING THIS PROJECT WERE SENT BY AIR EXPRESS FROM THE POINT OF ORIGIN TO SAN JUAN. THE USE OF AIR EXPRESS MADE IT POSSIBLE TO SHIP BENEFICIAL INSECTS IN THE ADULT STAGE AND THUS ENTIRELY ELIMINATE THE DANGER OF THE INTRODUCTION OF HYPERPARASITES IN SUCH SHIPMENTS.

IT SHOULD BE NOTED THAT IN GENERAL THIS METHOD OF SHIPMENT GAVE EXCELLENT RESULTS AND THAT A HIGH PERCENTAGE OF THE NUMBER SENT WAS ACTUALLY LIBERATED IN PUERTO RICO. THE RESULTS OBTAINED WITH INDIVIDUAL SPECIES WILL BE RECORDED IN LATER PAPERS.

FORTY-FOUR SPECIES OF BENEFICIAL INSECTS WERE INTRODUCED TO COMBAT SERIOUS CROP PESTS OF THE ISLAND.

DURING THE COURSE OF THESE INVESTIGATIONS THERE HAVE THUS FAR BEEN INTRODUCED INTO PUERTO RICO 44 SPECIES OF PARASITES AND PREDATORS TO AID IN THE CONTROL OF 14 MAJOR INSECT PESTS WHICH CAUSE ECONOMIC DAMAGE TO THE CROPS OF THE ISLAND. THE INSECT PESTS AGAINST WHICH THE PARASITES HAVE BEEN INTRODUCED ARE THE SUGARCANE BORER, *DIATRAEA SACCHARALIS*; THE PINK BOLLWORM OF COTTON, *PECTINOPHORA GOSSYPIELLA*; FRUITFLIES OF CITRUS, MANGOES, GUAVAS, AND OTHER FRUITS, *ANASTREPHA SUSPENSA* AND *A. ACIDUSA*; THE HORNFLY OF CATTLE, *HAEMATOBIA IRRITANS*; THE COCONUT SCALE, *ASPIDIOTUS DESTRUCTOR*; THE WEST INDIAN OR ROSE SCALE, *DIASPIS PENTAGONA*; THE BEAN POD BORERS, *ETIELLA ZINCKENELLA*, *MARUCA TESTULALIS*, AND *FUNDELLA CISTIPENNIS*; THE BANANA ROOT WEEVIL, *COSMOPOLITES SORDIDUS*; THE RED-BANDED THRIPS OF MANGOES, *HELIOTHRIPS RUBROCINCTUS*; THE PINEAPPLE MEALYBUG, *PSEUDOCOCCUS BREVIPES*; AND THE CORN EARWORM, *HELIOTHIS OBSOLETA*.

THE INTRODUCTION OF BENEFICIAL INSECTS TO PUERTO RICO WILL BE DISCUSSED IN DETAIL IN SEPARATE PAPERS FOR EACH SPECIES OF CROP PEST CONCERNED.

PAPERS DISCUSSING IN DETAIL THE INTRODUCTION AND LIBERATIONS OF THESE BENEFICIAL INSECTS ARE BEING PREPARED AND WILL BE PUBLISHED AS UNITS OF THE PRESENT SERIES OF "AGRICULTURAL NOTES". EACH HOST INSECT TOGETHER WITH ITS PARASITES WILL BE DISCUSSED IN AN INDIVIDUAL PAPER.